Overview of Generation IV and Advanced Fuel Cycle Activities

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Challenges to the Long-Term Viability of Nuclear Energy

Economics

- **Reduced costs (especially capital costs)**
- **Reduced financial risk (especially licensing/construction time)**

Safety and Reliability

- **Operations safety**
- **Protection from core damage (reduced likelihood and severity)**
- **Eliminate offsite radioactive release potential**

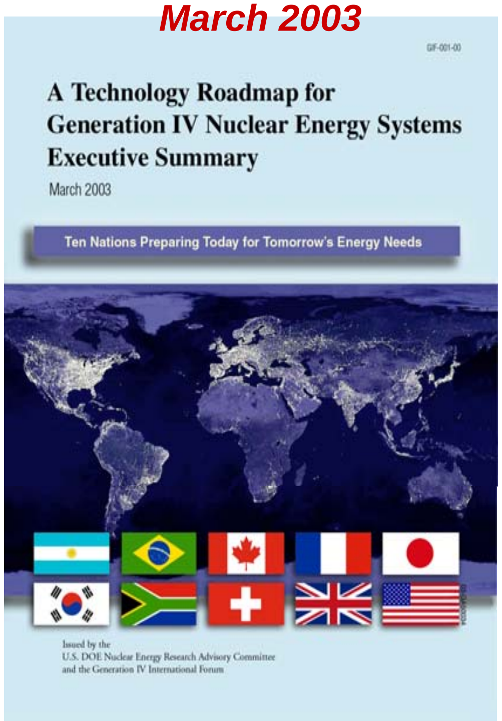
Sustainability

- **Efficient fuel utilization**
- **Waste minimization/management**
- **Nonproliferation**

Generation IV Technology Goals

- ***Generation IV program goals are aimed at developing Advanced Nuclear Systems that are deployable by 2030 or earlier and:***
  - ***Have adequate fuel resources and reserves for many years and a sustainable fuel cycle***
  - ***Are economically competitive with other energy alternatives***
  - ***Are even safer and more reliable than current technology***
  - ***Are exceptionally proliferation resistant and have additional protection against external threats***

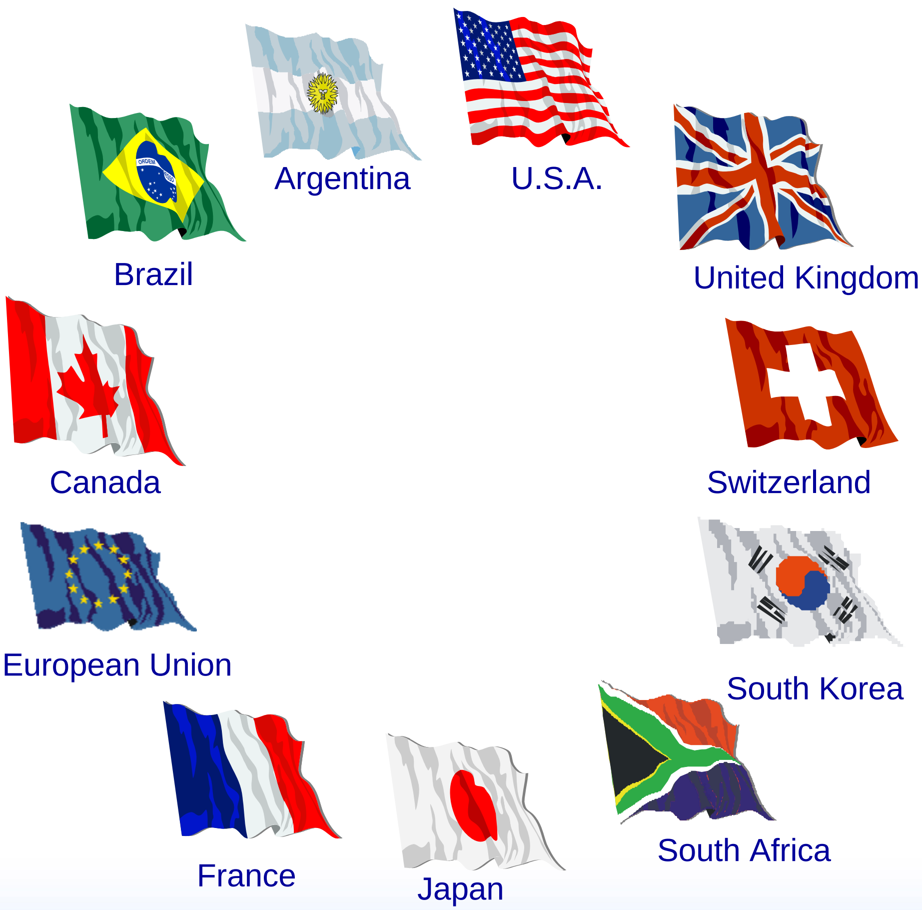
March 2003



http://gif.inel.gov/roadmap

Generation IV International Forum (GIF)

Chartered July, 2001



- ***Brings international perspective:***
  - ***Generation IV Technology Goals***
  - ***Evaluation of Systems and R&D***
- ***Endorses key elements:***
  - ***Six Gen IV Systems announced Sep '02***
  - ***Generation IV Roadmap***
- ***Identifies areas of multilateral collaborations and establishes guidelines for collaborations***
- ***Regularly reviews progress on collaborations***
- ***Observers from:***
  - ***International Atomic Energy Agency***
  - ***OECD/Nuclear Energy Agency***
  - ***European Commission***
  - ***Nuclear Regulatory Commission***
  - ***Department of State***

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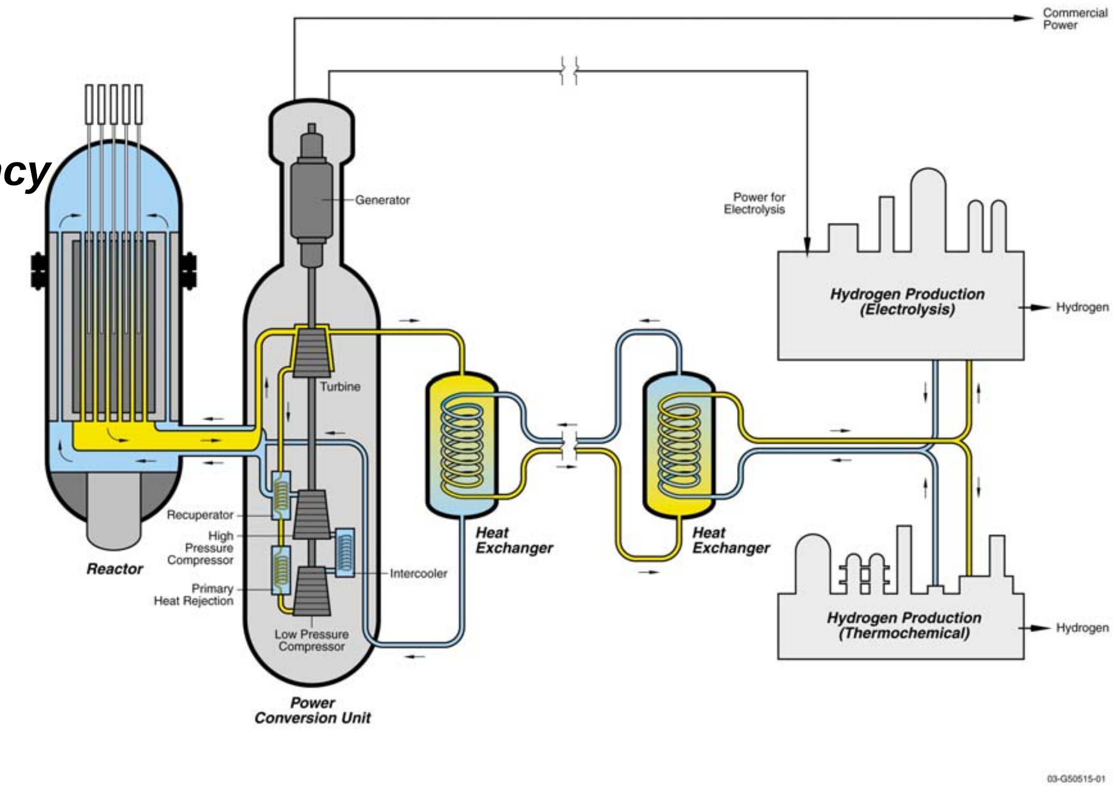
Very-High-Temperature Reactor (VHTR)

- ***Greatly Simplified Modular (150-300MWe) Design Lowers Capital Cost***
- ***High Outlet Temperature Improves Thermal Efficiency (850-950°C)***
- ***Hydrogen Production Potential Opens New Markets***
- ***Graphite-Ceramic Core Materials Improve Safety***
- ***Passively Safe to Loss of Coolant Accident***
- ***Coated Particle Fuel***



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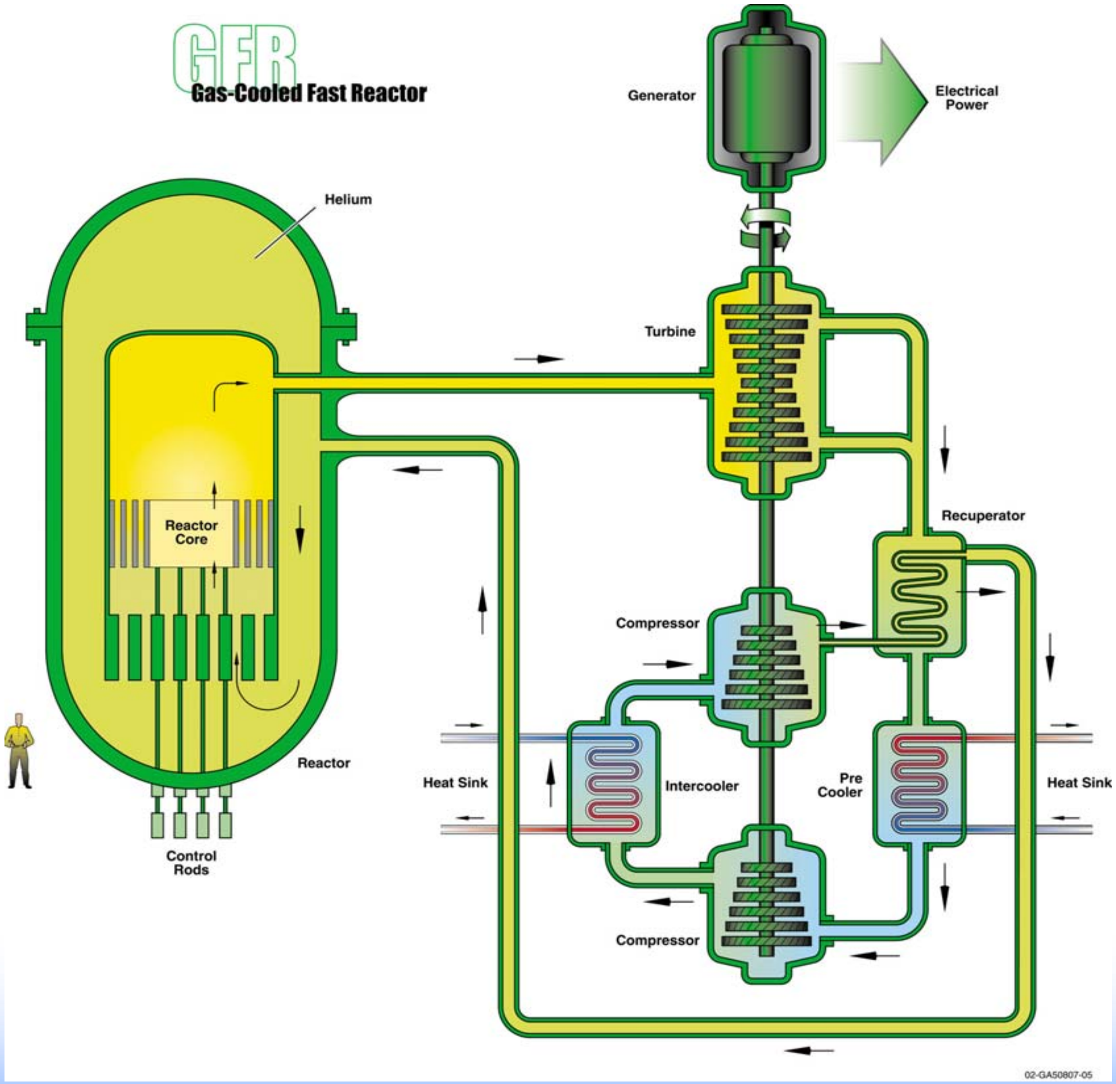
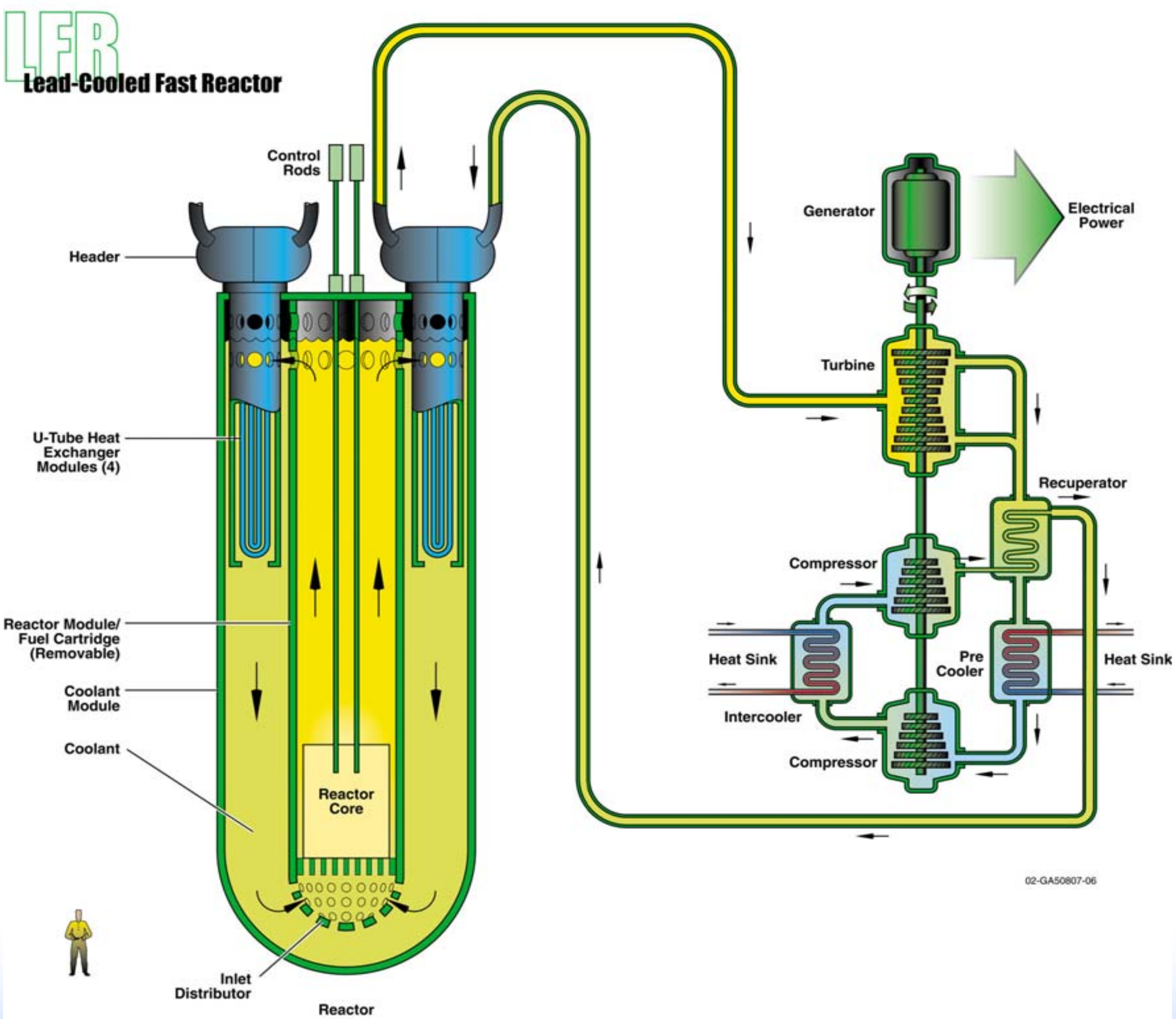
Gas Fast Reactor (GFR)

- *High level of safety*
- *High sustainability with a closed fuel cycle and full TRU recycle*
- *Fast- spectrum core*
- *Direct Brayton cycle, high-efficiency energy conversion*
- *Production of H_2*



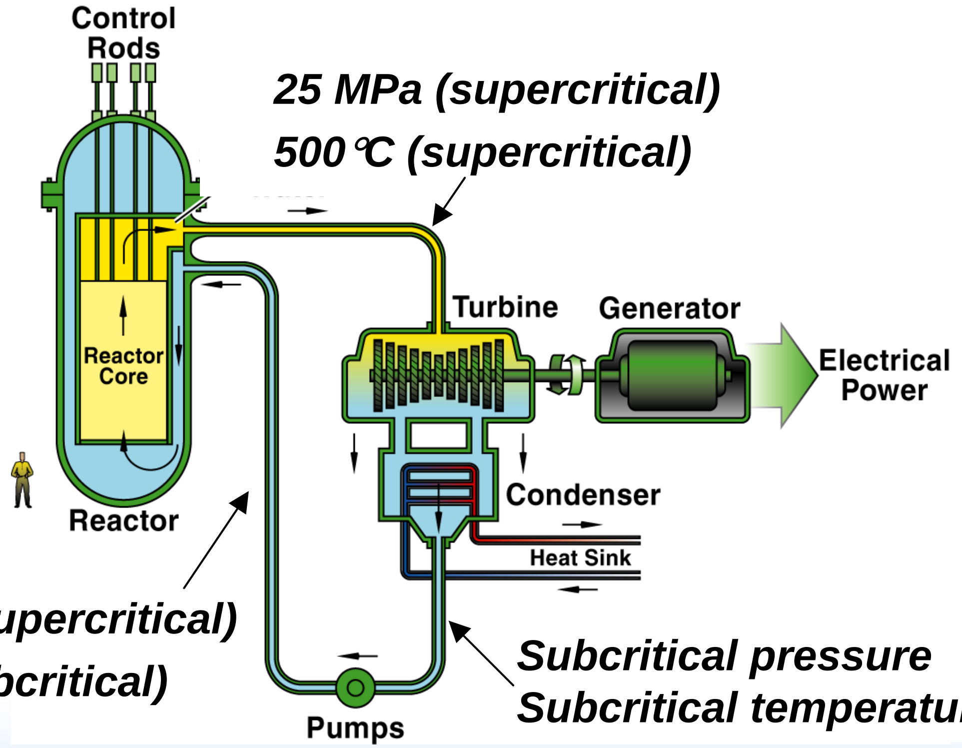
Lead-Cooled Fast Reactor (LFR)



- *High degree of proliferation resistance (current design includes 20-year core)*
- *Passively safe under all conditions*
- *Supercritical CO_2 energy conversion for >40% efficiency*

Supercritical Water Cooled Reactor

Major economic benefits expected



25 MPa (supercritical)
500°C (supercritical)

25 MPa (supercritical)
280°C (subcritical)

Subcritical pressure
Subcritical temperature

<u>Plant simplification</u>: no steam generators, pressurizer, recirculation pumps, steam separators or dryers.

<u>High thermal efficiency</u>: about 45% vs. about 35% efficiency for advanced LWRs.

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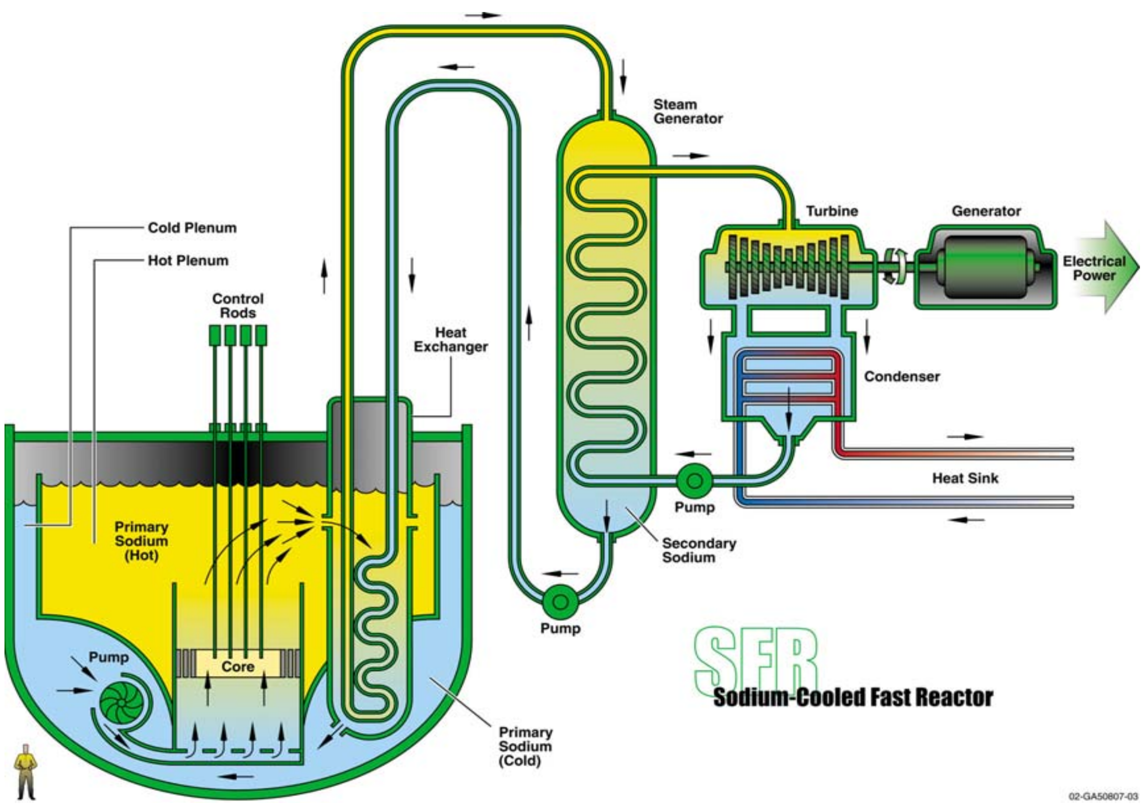
Sodium-Cooled Fast Reactor (SFR)

Characteristics

- *Sodium coolant*
- *550°C Outlet Temp*
- *150 to 500 MWe*
- *Metal fuel with pyro processing / MOX fuel with advanced aqueous*

Benefits

- *Consumption of LWR actinides*
- *Efficient fissile material generation*



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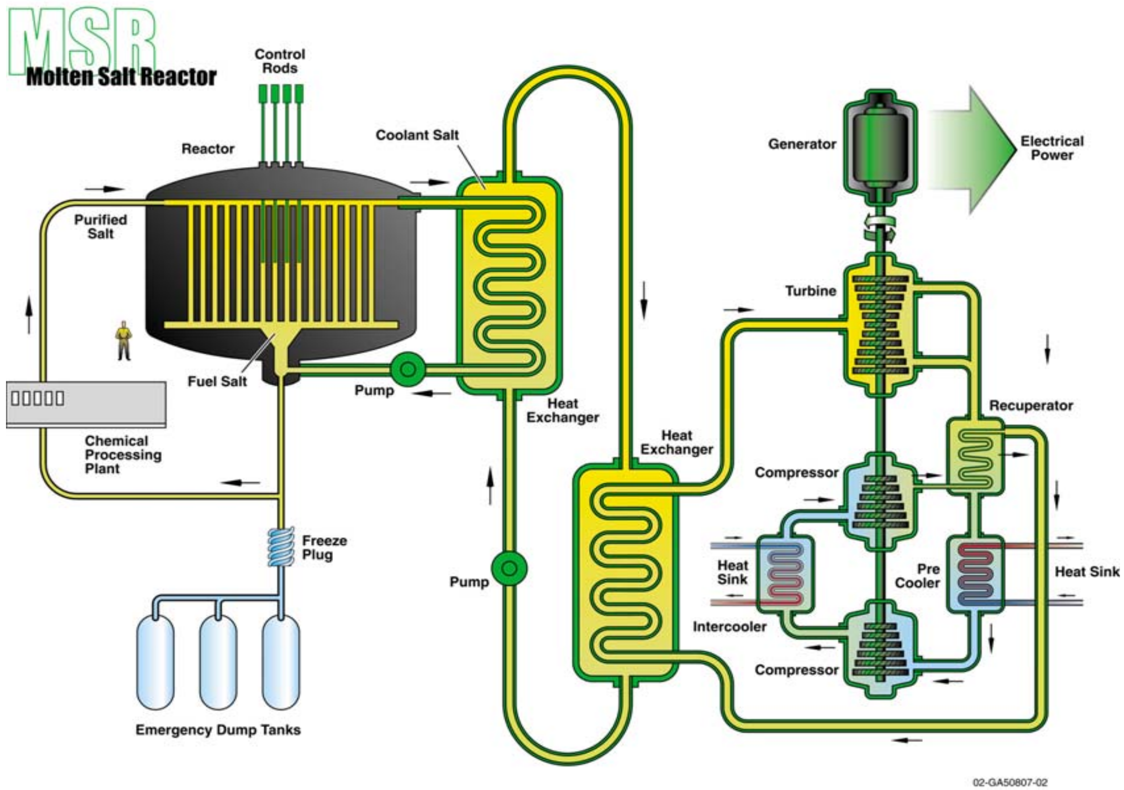
Molten Salt Reactor (MSR)

Characteristics

- ***Fuel: liquid Na, Zr, U and Pu fluorides***
- ***700–800°C outlet temperature***
- ***1000 MWe***
- ***Low pressure (<0.5 MPa)***

Benefits

- ***Waste minimization***
- ***Avoids fuel development***
- ***Proliferation resistance through low fissile material inventory***



There are a variety of motivations for implementing fuel cycle that includes recycling

- ***Program implementation must be consistent with and supportive of***
  - ***Multiple objectives***
  - ***Externalities (including both national and international)***
- ***National Motivations:***
  - ***Optimal use of repository (ies)***
  - ***Near-term management of spent nuclear fuel***
  - ***Recovery of energy value in SNF (natural resource utilization)***
- ***International Motivations:***
  - ***Global nuclear-materials management options***
  - ***Guidance for policy decisions on governance regimes***
  - ***Leadership in defining advanced systems for proliferation resistance***

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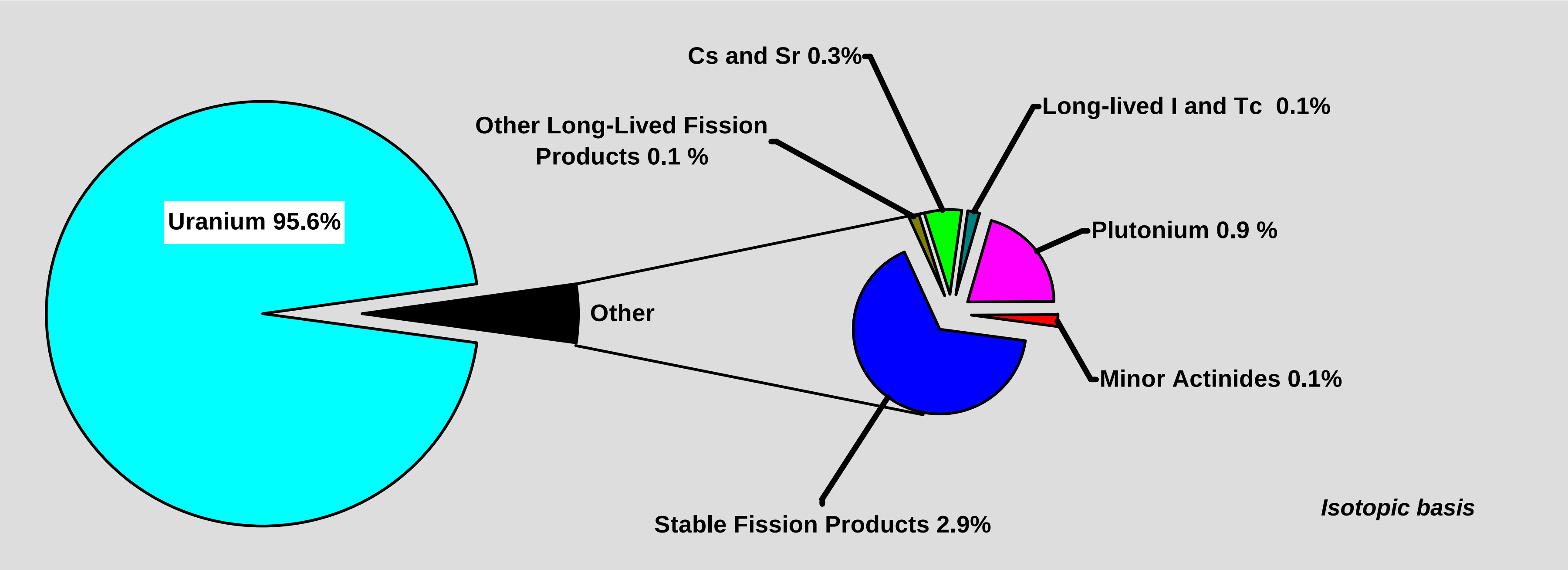
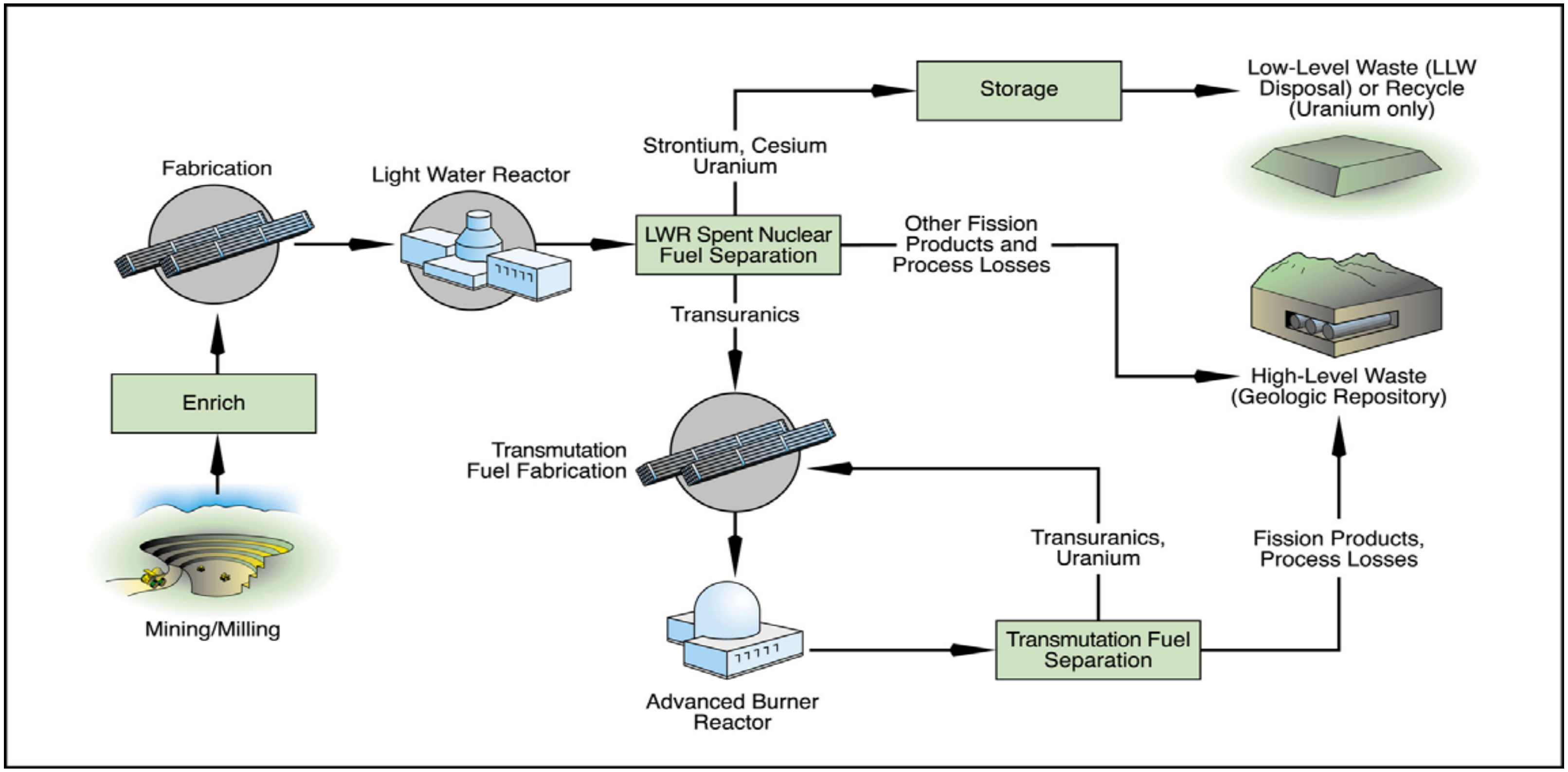
Global Nuclear Energy Partnership Requirements

- ***The system must result in a significant improvement in repository utilization, preferably avoiding the need for a second geologic repository this century***
- ***The system must optimize waste management including minimizing waste that needs to be handled or stored, and producing only solid waste with robust waste forms***
- ***The system must make available the energy value of separated materials for future use***
- ***The system must reduce proliferation risk***
- ***The system must be deployable in a timeframe so as to reassert U.S. leadership, and influence fuel cycle development worldwide (20 years)***
- ***The system must remain as economical as possible***
- ***The system must be environmentally sound***

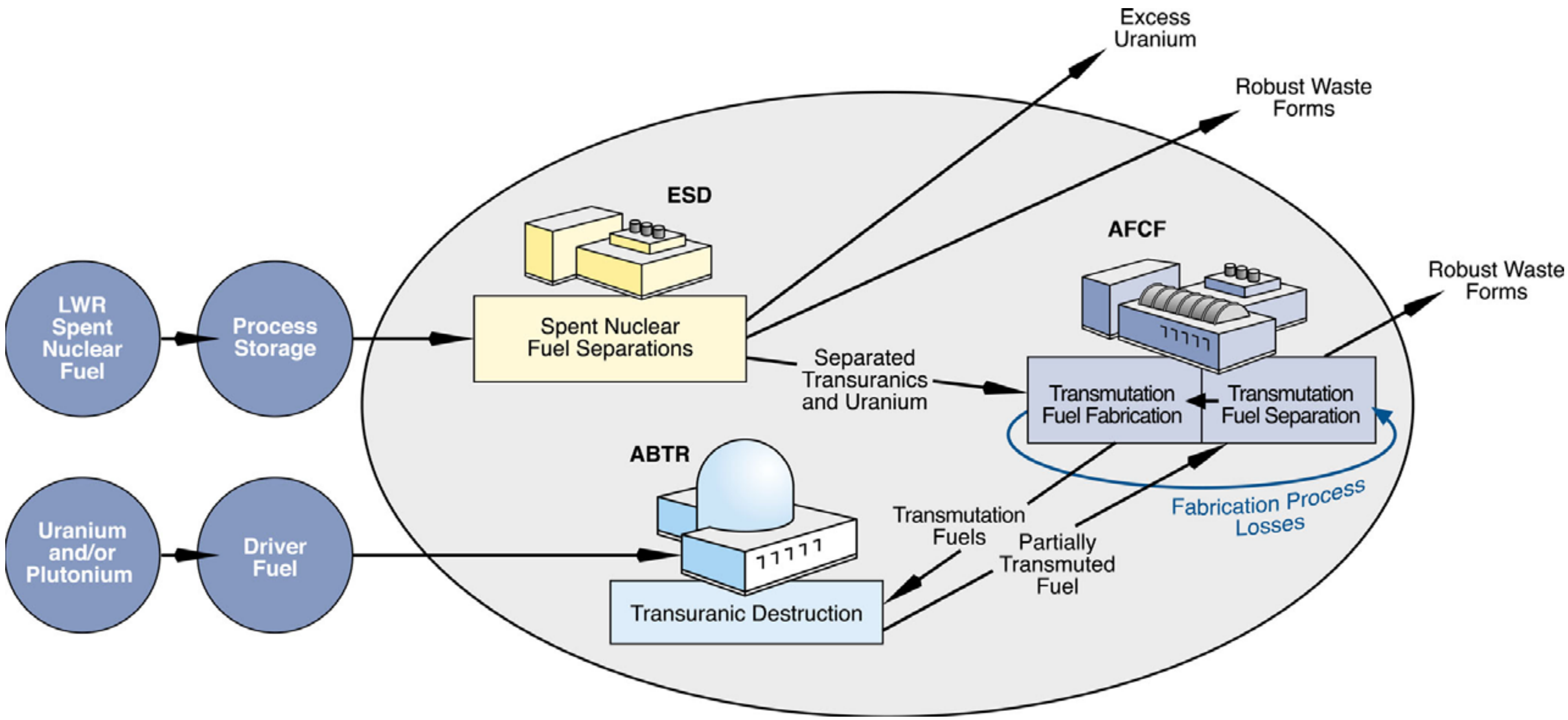
Used nuclear fuel (less cladding)



GNEP Deployment System



GNEP Technology Demonstration Facilities



Summary and Implications for the Future

- ***Economics, operating performance and safety of U.S. nuclear power are excellent***
- ***Nuclear power is already a substantial contributor to reducing CO_2 emissions***
- ***Nuclear power can grow in the future if it can respond to the following challenges:***
  - ***remain economically competitive***
  - ***retain public confidence in safety***
  - ***manage nuclear wastes and spent fuel***

- ***Nuclear power's impact on energy security and CO_2 emissions reduction can increase substantially with increased electricity production and new missions (hydrogen production for transportation fuel)***
- ***The DOE Generation IV program and the Global Nuclear Energy Partnership are addressing addressing next generation nuclear energy systems for electricity, waste management, and hydrogen***

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